INTEGRATED PRODUCT DEVELOPMENT/LEADERSHIP TRAINING CASE STUDY

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ABSTRACT

Integrated Product Development(IPD) and Integrated Product Teams (IPTs) are important in industry today because teams can accomplish more in less time, with higher quality, than working individually and passing work along. This paper is a case study of IPD/IPT Leadership, an accredited course taught at The University of Akron (UA). The study consisted of a two-semester (Fall 1995 & Spring 1996) evening class available to industry and UA students, taught by a representative from industry with IPT experience (the primary author).

The main reasons teams fail are inexperience in operating as a cohesive team, and a reluctance to openly share ideas, trust actions, and agree on results. The answer is training.

During training, leadership roles/duties were defined, with each student given numerous opportunities to participate, lead and present to the class. All leadership positions on the team were rotated, some elected by the team, others assigned by the instructor. Many team projects were used throughout the course, providing the students with many opportunities to work on unique projects and requiring them to interact with other class members. As students gained experience and confidence in operating as teams, team dynamics dramatically improved, allowing the teams to efficiently move forward with their tasks.

A review of teaching techniques and obstacles to teaching this type of class will be addressed.

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What is Integrated Product Development (IPD)? The nontechnical definition of IPD is having multitalented people work together as an empowered team from the onset of a project to develop, design, or manufacture a product and/or process. The product can be a weapon system, manual, computer, or even a trained individual.

Why is IPD important? IPD is the key to improving competitiveness through improved customer satisfaction, reduced development times, increased employee ownership, reduced cost, and fewer changes.

What is the case study? A joint industry/university partnership in which students learn to work in teams and develop leadership qualities. This partnership resulted in a two-semester accredited undergraduate evening class offered at The University of Akron (UA). The class was open to industry and student enrollment, with no prerequisite, and was taught jointly by the primary author and several other instructors.

Why is there a need for training in IPD? The reasons are many:

- There is a general reluctance for people to share ideas, trust each other, and agree on a common solution in a timely manner. This includes the WIIFM obstacle, **W**hat's **I**n **I**t **F**or **M**e, which creates problems.
- Universities excel at teaching students how to take exams, how to work individually, and how to be motivated individually, but *not* how to work together as a team.
- Competitive environments throughout the military and commercial sectors must become leaner, faster, and better, improve quality, and better define and reduce risk.
- Case studies have shown that workers involved in the decision-making process take ownership of the outcome of the team.
- Build and fix cycles must be broken, where a product is developed, designed, built, tested, and then modified and tested again, leading to higher costs and late delivery.
- In industry, the walls between functional organizations must be broken down.

The answer to these issues is training.

The goals of the IPD class were to empower the students to work effectively and efficiently as teams, feel confident leading teams, gain an appreciation of several technical enabling technologies, and agree that IPD teams are a solution to many of industry's problems.

The makeup of the class was unique; 16 of the students were Lockheed Martin employees and two were UA students. Student participation was low, since the class was a late addition to the "Special Topics" curriculum. The structure of the class was relaxed and open, to better accommodate team building.

COMMUNICATION AND TEAM BUILDING

For team building, class members first performed a series of exercises individually. Later, the same assignment was given as a team exercise. The objective was to convey that better decisions/solutions can be achieved when working as teams. Group communication guidelines were established as follows:

- Do not criticize.
- No ideas are to be discarded without evaluation.
- Respect other members' feelings.
- Do not interrupt.
- Have fun.

Listening guidelines were also presented. They were:

- <u>Stop talking.</u>
- Hold your temper.
- Be patient.
- Put the speaker at ease.
- Show a desire to listen.
- <u>Stop talking.</u>

The responsibilities of the team leader, secretary, presenter, and facilitator were all presented and discussed, as well as decision-making options as a team. Whether as a consensus, majority or dictatorial approach, decision-making as a team was discussed in detail. As the class became familiar with team operation, they wanted to tackle all class problems as a team, including taking the mid-term and final exams, which was where the teamwork was stopped.

Musical Chairs Exercise: In industry, people on teams go on vacation, get sick, are absent, retire, or are reassigned to other teams. As a result, teams need to learn how to regroup and continue to move forward. The same problem was assigned to four different teams. After team discussion and even some decision-making, team members were randomly rotated to other teams. In some instances, the team leader was reassigned, forcing the teams to select a new leader. Team dynamics were reestablished, but in all cases, moving ahead to meet deadlines was stressed. Only a limited amount of revisiting previous commitments could be done. This forced the teams to move ahead, no matter what the obstacles were. After much grumbling initially, the teams got used to this game of musical chairs every couple of weeks, and became very good at recovering and continuing the progress.

EMPOWERMENT

Teams need empowerment, otherwise ownership and team dynamics are stifled, and they run the risk of failure. The most successful case studies documented are those in which the team is given full empowerment and responsibility for their decisions. Teams in this case study were given full, unlimited empowerment. Teams must be empowered to do not what the *team* wants, but what the *customer* wants.

TEAM LEADERSHIP

The teams were presented with the following leadership qualities:

- Keep the team focused and moving ahead.
- Be dynamic.
- Be able to see the "Big Picture," yet give attention to detail.
- Be a mediator.
- Lead by example.

Another project given to the class was a role reversal of sorts. Individual students were asked to generate a class evaluation form containing everything that they, now the customer, would use to evaluate the instructors, now the suppliers. They were then put on teams and the lists of questions were condensed, combined, and improved. The purpose of this exercise was to expose the students to an assignment for which none of them had experience, something that occasionally happens. This was met with some reluctance, until they discovered their individual responses were to be graded. Many very good evaluation questions were received that ultimately made up the backbone of the semester evaluation given to class members.

Numerous projects were assigned to the class so that new teams were constantly being formed and new leaders selected. One class objective was to develop leaders and foster the growth of leadership qualities in team members, so they would be comfortable leading as well as participating on teams.

Leadership Challenge Exercise: In some team assignments, leaders were appointed, while in others, the leaders were elected by the team. Eventually, everyone in the class was put in a leadership role multiple times. After a while, popular leaders emerged along with popular followers. The challenge to the class, although they were not aware of it, was to assign all of the popular leaders to a team and all of the popular followers to another team. This caused each team to struggle a bit more than usual in electing a team leader, but did not appreciably affect the outcome of the team. This exercise was an attempt to have the teams interact with team members having similar types of personalities, something that often occurs in industry.

PROJECTS

A number of different projects were assigned throughout the two semesters. Many were real-life examples from industry, and others were unusual projects. The major real-life project assigned was a Stabilization and Orientation System (SOS), part of a generic rocket motor. The fictitious SOS was an overbudget, late field failure, ripe for improvement. The system had functional (quality), cost, and delivery problems, violations of the three most important aspects of a program. The class performed limited failure analysis to determine why the system failed (stress analysis application), then modified the design (CAD exercise) and remade it (CNC programming) to be functional, within budget, and within the due date. Many evaluations of SOS concepts were made. At the conclusion of the second semester, the class visited the Lockheed Martin Tactical Defense Systems plant, where the final design of the SOS base was manufactured on a CNC Machining Center, and inspected using a Coordinate Measuring Machine.

CUSTOMER-DRIVEN DEVELOPMENT AND DESIGN

The class learned that the most important drivers in product development and design are the customer's requirements, needs, and satisfaction, or the "Voice of the Customer." This Voice of the Customer was interpreted and applied in class exercises. The class also discussed having the customer or customer representative, e.g., Defense Contract Management Command (DCMC), participate on the IPD team, and involving the customer in the early definition of the product and process. Quality Function Deployment (QFD) was broken down into the individual rooms that make up the "House of Quality." The House of Quality converts customer input into the technical output required to technically develop the customer's product and process. The goal is to prevent any misinterpretation of the customer's needs, concerns, and expectations.

Customer Exercises: Who better to be the voice of the customer than the person grading the students? The instructor was the customer in the exercises performed in class. In most cases, the teams took advantage of having the customer available, although in early exercises, they didn't even acknowledge him. A second exercise attempted to combine learning with a little fun -- physically building the House of Quality from construction paper, using blunt-nosed scissors and tape. The goal here was for class members to understand each room in the house and its impact on the product. Even though the students had a lot of fun cutting and building the paper house, they all admitted they wouldn't soon forget the House of Quality.

IPD ENABLING TECHNOLOGIES

IPD tools and enabling technology are anything that facilitates IPD actions. Technical tools discussed in class included Computer-Aided Process Planning (CAPP), Computer-Aided Design (CAD), Computer-Aided Engineering (CAE), QFD, Process Flowcharting, Group Technology (GT), Rapid Prototyping Process (RPP), Geometric Dimensioning and Tolerancing (GD&T), and Design for Manufacture and Assembly (DFM/A). Most of the enabling technologies were covered in detail, as much as time permitted.

CAD Exercises: Class members were initially required to design several parts of the SOS assembly. They drew the existing design of the SOS base to gain experience using the CAD system. After the teams analyzed and brainstormed the shortcomings of the base, they revised the CAD design to incorporate their improvements.

CROSS-TRAINING EXERCISES

Throughout the two semesters of the class, students were given hands-on exposure to several technologies. They were CAD, available in the university's computer lab, mechanical stress analysis, and CNC programming, available in UA's programming lab. Stress analysis became part of the team's problem-solving actions as they compared mechanical designs for strength. This exposed them to the analysis and design side of a product, since many students had no relevant experience. CNC programming was added to give the students a flavor of the hands-on manufacture of a product, the SOS base.

DESIGN FOR MANUFACTURE / ASSEMBLY (DFM/A)

Since design accounts for approximately 5% of the product cost, yet influences about 70% of the product cost, it is an important place to begin addressing cost. Using DFM/A, designs are analyzed for ease of manufacture and assembly. This discussion centered around brainstorming to reduce and simplify manufacturing and assembly, then measuring the impact to cost. This was done using Boothroyd Dewhurst Inc. (BDI) DFM/A software modules. Real-time cost impacts were immediately measurable.

DFM/A Exercise: In redesigning the SOS assembly, four teams came up with four different solutions. The BDI software was used to evaluate each of the designs and aided in the decision-making for downselect to one concept.

PROCESS FLOWCHARTING

Process flowcharting is also important in IPD because all products must eventually be produced in one manner or another, whether that product is a trained pilot or hardware, such as the SOS base. The approach used to achieve a finished product must be an orderly, well-thought-out procedure. The method of flowcharting the production process was presented to the class. The simple one-sheet-of-paper approach was the key to understanding the entire process, and students could compare concept flowcharts in formative brainstorming periods. Flowcharting also facilitated review of the different approaches by the customer (instructor).

Flowcharting Exercise: The teams were assigned problems to be flowcharted. The flowcharts were then presented to the class by the team presenter. Because the flowcharts presented the information clearly and simply, the class was able to understand and critique the approaches presented.

DECISION-MAKING CHARTS

Any time a team works together to solve a problem, team members will invariably disagree and end up with several possible solutions. Decision-making charts were implemented that identified all of the possible solutions, then identified the evaluation criteria used to select the best solution. These criteria come from the output of the House of Quality, where customer needs, including cost, function, aesthetics, etc., are used directly to select the most viable option. Other important criteria were used to help decision-making, such as process availability, lead times, and market information. Each of the criteria was weighted for value, based on perceived importance to project success. This approach not only speeds up the decision-making process, but it also documents alternative approaches considered, but not used.

Decision-making Exercise: The teams used the original decision-making process of equally weighting all evaluation criteria until they felt that one or two criteria were more important than others. After class discussion on weighting of criteria, they were given the freedom to weight the evaluation criteria according to what each team thought was most important. The output from the four teams was almost identical, even though they arrived at three different solutions. This was due to the fact that three of the four concepts presented were very similar. The exercise was the evaluation process, not arriving at the same answer.

MEASURE FOR SUCCESS

Measuring for success is vitally important to any IPD project. The questions are: What to measure? How to measure it? What metrics are used? The ultimate measure of success has to be "Is the customer satisfied?" If the answer is yes, then you have success. But other more quantifiable benchmarks can be used, including reduced cost, fewer engineering changes, and reduction of lead time. More subjective evaluators include management approval and team ownership of the product. All of these are important aspects, not to be ignored, but ultimately each IPD team has its own unique set of guidelines and requirements. For class members, the measure of success was based on how well they led a team and participated on a team, along with grades on the mid-term, final exam, quizzes, homework, and attendance. The work the teams did at UA was very successful; all team members received above-average grades.

OBSTACLES TO CLASS SUCCESS

There were a number of obstacles to class success. The primary author had no experience developing accredited UA classes, only in teaching them. There were no textbooks available, which forced the students to work out of notebooks and created a mountain of work for the instructor. Because the makeup of the class was mostly professionals from Lockheed Martin, students and instructors were subject to occasional business travel, causing delays in many planned activities. Another problem common throughout industry as well as on the academic level is: How do you evaluate or reward individuals working as a team? This was resolved by giving individual grades en route to working in teams, then giving team grades.

RESULTS AND SUMMARY

The results and the summary of the class are divided into two areas -- a student perspective, and a teacher perspective. The overall scores on the students' evaluations were very good, and lots of positive feedback and comments were received. Most comments were very helpful, including second semester changes to have class one night versus two nights a week, and to start class at 5:00 pm instead of 6:00 pm. Student participation was excellent, and there was lively classroom discussion.

From a teacher perspective, this was a very difficult class to teach. It was a logistics nightmare coordinating and scheduling 4 to 5 instructors in 2 to 3 campus labs, at two different sites (UA and Lockheed Martin). It was also very hard to teach coworkers, who made up the majority of the class. On a positive note, it was tremendously gratifying to see class members begin to apply the fundamentals of IPD and to take charge of the teams. So, in spite of all the work, it was a very enjoyable and even fun class. A number of students even personally thanked the instructors for their efforts.

CONCLUSION

The class was an overwhelming success. Students grew in their ability to rapidly form teams, adjust to the curve balls thrown at them, and exceeded all the instructors' expectations. More importantly, leadership skills were honed, so that each student felt comfortable leading an IPD team, no matter who was on it.

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